Abstract

Rhythms are amongst the most conspicuous properties of nature as well as of living systems. Very often the rhythmic oscillation is not apparent from the observations so it remains a challenge to search for the hidden regularity in terms of the embedded periodic components. A new method for periodicity detection detection is proposed where unlike available methods a periodic component is characterized in terms of three basic periodicity attributes: the periodicity (or period length), the periodic pattern and the scaling factors associated with the successive nearly repetitive segments. A scheme is proposed for subsequent successive detection and extraction of such hidden periodic or nearly periodic components constituting an irregular cyclical series. The proposed decomposition is much more powerful in terms of information content and the robustness than the available tools based on Fourier decomposition.

The method is completely data adaptive. The unique features of the proposed scheme of decomposition are that the individual periodic components may not be sinusoidal and the successive segments may be scaled dynamically. An inherent advantage of the proposed decomposition is that long term prediction is possible here because the conventional p-step ahead prediction renders to p-period ahead prediction.

The framework of deterministic chaos provides a new approach to the analysis of irregular signal. The scope of these methods ranges from dynamical invariants such as dimension which indicates a nearly accurate descriptions in physical terms (if the data are of high quality) to statistical techniques (the method of surrogate data) which can be used for the classification and diagnosis where the determinism may be very weak.

Through the analysis of variety of natural (solar oscillations), experimental (chaotic laser), simulated (Rossler series, Mackey-Glass series, Logistic map), epidemiological (measles and chickenpox series), and physiological (ECG and EEG) signals, it is shown that the proposed scheme of decomposition combined with different approaches of nonlinear dynamical system theory can lead to meaningful characterization of an irregular signal in a new perspective.